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ADOPTION OF BLOCKCHAIN TECHNOLOGY IN FOOD SUPPLY CHAIN MANAGEMENT

Creative Component presented to the faculty of

Management Information Systems

Ivy College of Business

Iowa State University

In partial fulfillment of the requirements for the

degree of Master of Science

Program of Study Committee:

Dr. Anthony Townsend

By

Sripathi Lakshmi Sailaja

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Abstract

Blockchain, in general, used as a synonym for Bitcoin is more than that. Recently, Blockchain is expanding its application in various segments other than cryptocurrency, and Supply Chain is major among them. Introducing Blockchain in Food Supply Chain enhances building trust among stakeholders and consumers. For example, the Fijian company uses Blockchain technology to track the supply chain of Tuna fish through a program called *Bait to plate* where a consumer can check the history of the fish he is about to eat. Sounds interesting! Customers can now trust that the food they are consuming is safe.

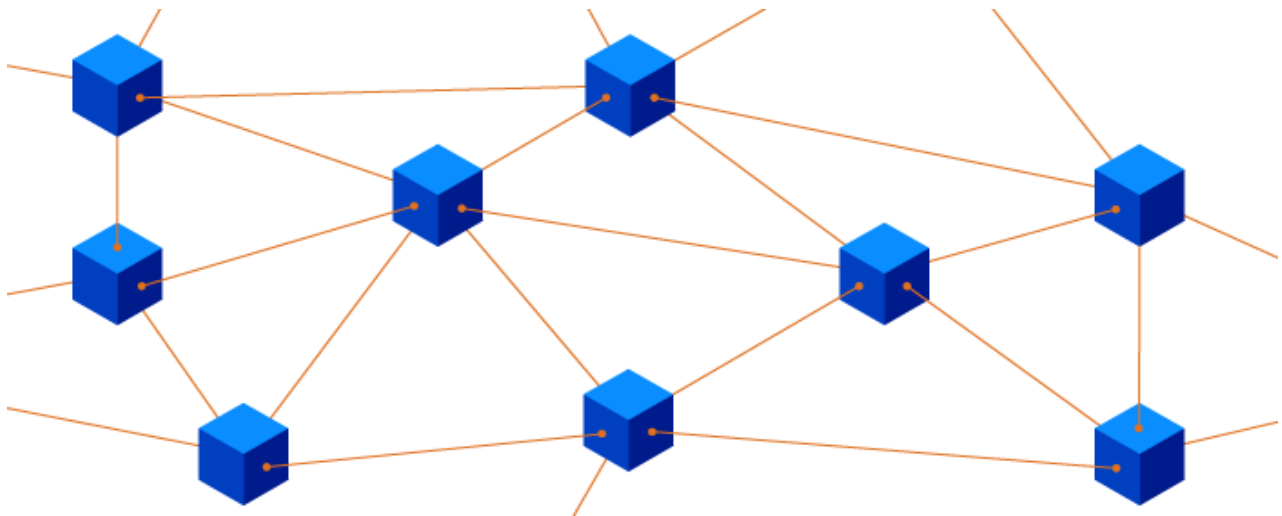
With all the opportunities enabled by Blockchain, many companies are still skeptical about its adoption. This research aims at addressing the factors affecting the adoption of Blockchain by a firm in the Food Supply Chain industry. The factors viz. size of the firm, IT investment, number of stakeholders within the supply chain, and perception of risk of early adoption are the independent variables, and the adoption of Blockchain technology is the dependent variable. In later sections, Blockchain and its current and potential applications in the food industry are discussed in detail, followed by proposing the expected relation between these independent and dependent variables. A survey should be further conducted to test and examine the correlations statistically.

Keywords: Blockchain, Food Supply Chain, Technology Adoption Lifecycle.

Introduction

“A Blockchain is a distributed database, which is shared among and agreed upon a peer-to-peer network. It consists of a linked sequence of blocks (a storage unit of the transaction), holding timestamped transactions that are secured by public-key cryptocurrency (i.e., “hash”) and verified by the network community. Once an element is appended to the Blockchain, it cannot be altered, turning a Blockchain into an immutable record of past activity.”

-Seebacher & Schuritz



Blockchain is nothing but a distributed ledger database made of blocks. Each block in the database is linked to the previous one chronologically. Each block in the chain consists of a set of transactions, verified by each person within the network.

A hashing algorithm is used to generate a complex hash code using the current block transactions and the hash code of the previous block. Once the block gets appended to the chain, a transaction completes, and it is impossible to alter the data.



Source: RubyGarage – How the blockchain works - by Tania

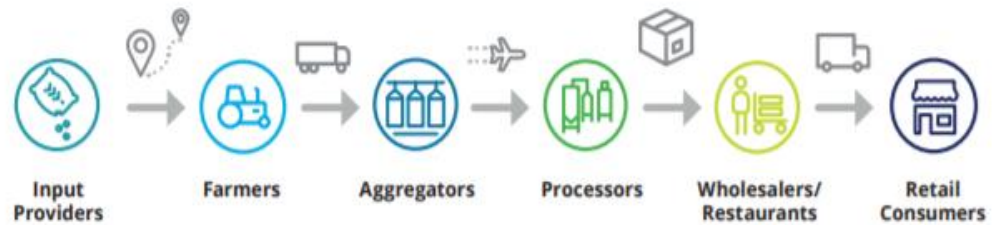
The most extensive applications of Blockchain are in the cryptocurrency domain. Cryptocurrencies, like Bitcoin, has changed the way financial transactions can happen without any middleman. Each operation within the Bitcoin network is transparent to every member in the network and validated by a group of miners. The cryptography system uses a combination of the public and private key for authentication. The public key is the one shared with the other parties while a private key is kept secret and used for authentication and encryption purpose. The irreversible nature of the currency exchange leaves a marginal room for fraudulent activity.

Blockchain can bring a revolutionary change in the Food Supply Chain industry. The current Food Supply Chain lacks in ensuring the trust of food hygiene to the consumers. According to the Centers for Disease Control and Prevention (CDC), every year, 1 in 6 Americans get sick, 128,000 get hospitalized, and 3,000 people die of foodborne diseases. By tracking the food we consume at each stage, Blockchain can ensure food safety and build trust in consumers. Fig 1 shows the impact that Blockchain can bring to the Food Supply Chain.



Food supply chain

Today



Tomorrow

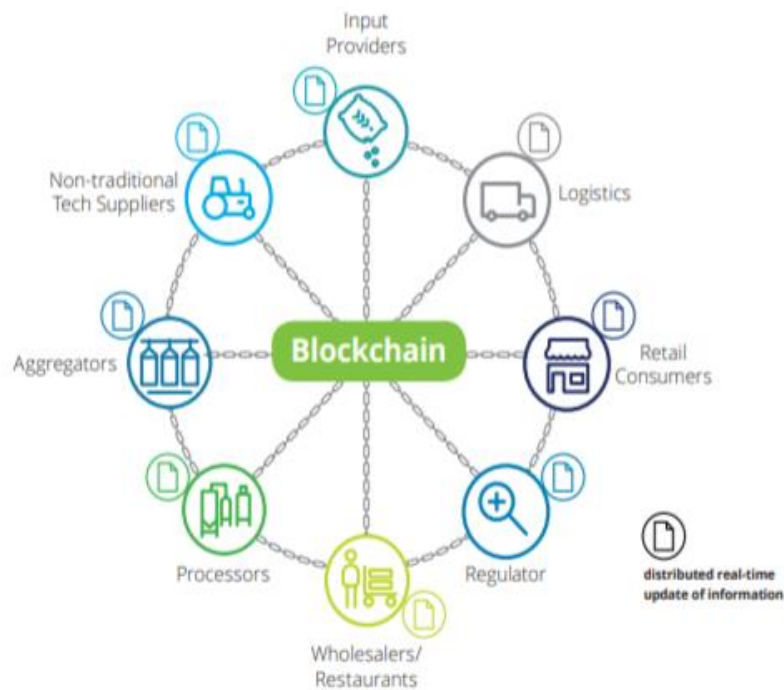


Fig 1 Food Supply Chain by the adoption of the Blockchain

Image Source: When two chains combine / Supply chain meets blockchain, (2017) Deloitte Development LLC

There are many challenges in the adoption of the Blockchain in various industries. Some of the concerns displayed by the companies include lack of clarity on the technology, finding the expertise to develop and handle the technology, finding the right technology platform, integrating

with the legacy systems. Besides, security and visibility of the transactions to the potential competitors is a foremost obstacle for the implementation. Private Blockchains provide the opportunity to the members in the Blockchain to keep their information secure. In the upcoming years, private Blockchains will play a prominent role in sectors handling sensitive information like medical records, Social security details, financial transactions, etc. (swan 2016).

Technology giants as IBM, Microsoft, and Oracle, as well as numerous startups, develop software that uses Blockchain technology to track products through its supply chain called as Blockchain as a Service (BaaS). BaaS allows customers to leverage cloud-based solutions by using Blockchain services while the service provider manages the infrastructure. For example, a website, www.chetu.com provides different services to food suppliers to help adoption of traceability in the supply.

As like any other technological innovations, Blockchain also has limitations. The processing speed of each transaction is quite slow, with the consumption of a massive amount of energy. Popular currency - bitcoin can process only 4.6 transactions per second. The energy consumption of bitcoin alone is higher than 159 individual countries. However, technological advancement can improve the performance of the Blockchain infrastructure. The pioneers of the technology and researchers are working towards building Blockchains that are swifter, energy-efficient, and sustainable.

Research Question

Blockchain is a significantly mature technology, and its applications are ubiquitous. With all the numerous benefits of the technology, researchers are exploring more and more domains and industries where Blockchain can improve and simplify the business. Notwithstanding primary sectors as food, health, and education are skeptical about espousing Blockchain. There is a research gap to identify the reasons that are blocking the implementation of Blockchain. This paper aims at finding the aspects causing hindrance to the adoption of Blockchain in Food industry.

“What are the factors affecting the adoption of Blockchain by a firm?”

To elaborate the above question to the scope of current research,

“How does the perception of the risk in early adoption, size of the firm, IT investment, and the number of stakeholders in the Supply Chain affect the adoption of Blockchain by a food industry?”

The scope of the research is to understand and propose how do the above variables affect the adoption of blockchain in the Food Supply Chain.

Literature review

Blockchain is a technology coined for the escape from government protocols and bank-controlled payments through the famous cryptocurrency Bitcoin. Blockchain is a type of distributed ledger technologies (DTE), almost all of which have emerged in Bitcoin's birth in the year 2009. According to *statista.com*, Bitcoin has over 40 million of bitcoin wallets at the end of June 2019 and increasing rapidly. Along with the success of cryptocurrency, many other potential applications of blockchain are being implemented in various domains.

Blockchain Applications

Originally developed and widely adopted as the backbone of the cryptocurrency. Started with famous Bitcoin, and later many more cryptocurrencies have been introduced viz. Ethereum, Ripple. By August 19th, 2018 there are around 1600 cryptocurrencies with Bitcoin being the largest Blockchain network followed by Ethereum and Ripple.

"The blockchain is an incorruptible digital ledger of economic transactions that can be programmed to record not just financial transactions but virtually everything of value."

-Don & Alex Tapscott, authors Blockchain Revolution (2016)

Blockchain is more than cryptocurrencies and can be used in various other sectors to secure transactions. Some of the potential applications of Blockchain are in finance, Internet of Things (IoT), public and social services like land registration, energy-saving, education, etc., (Blockchain

challenges and opportunities: a survey by Zibin Zheng and Shaoan Xie). Smart contracts, an application of Blockchain technology, can help introduce the distributed ledger into these different industries. A smart contract is a self-executing contract without any human intervention. It self-executes when certain predefined conditions meet between the two parties involved in the transaction. Ultimately, it will create a more transparent, trustworthy, and conflict-free environment.

Blockchain in Food Supply Chain

One of the potential industries with a revolutionary change by adopting Blockchain is the Food Supply Chain. There are many recent advances in the practical application of Blockchain into the Food Supply Chain industry. A Fijian tech startup called TraSeable along with a Brooklyn based blockchain company Viant is piloting a supply chain system that uses a combination of radio-frequency identification chips and QR codes to track tuna on a blockchain-based platform for a small fishing company called Sea Quest.

Walmart, one of the largest retailers of food, invested in Blockchain technology to trace the origin of pork in China to its consumption in the United States. Walmart is also working with IBM Blockchain to follow the supply chain of leafy green vegetables. 42% of the companies within the retail and manufacturing sectors are planning to spend around \$5 million in tracking the Food Supply Chain (Ramamurthy, 2016). Walmart, Nestle, and many other large companies are investing in building Blockchain to track food worldwide and ensure food safety and hygiene. Subway is one of the food chain aiming to embrace advanced technologies as Blockchain for the smooth and efficient tool for success in business.

The marking and tracking technologies like RFID (Radio-frequency identification), NFC tags, QR code, and similar Internet of Things (IoT) technologies can aid to achieve traceability in the supply chain. Consumers, suppliers, distributors and all other stakeholders involved in the food distribution string can scan the code attached to the product and can retrieve the entire supply chain of the product from the producer to the consumer. With this induced transparency in the supply chain, suppliers are forced to adopt socially responsible practices to either match their competitors or gain a competitive advantage over them. The traditional supply chain is in place over a long period; hence, making changes to it is a tedious and intricate process. Undoubtedly, integrating new technology into the traditional supply chain is very hard and incurs high costs because of the necessary modifications to legacy systems (Mougayar, 2016). This change demands approval and acceptance from a large number of stakeholders of the Supply Chain. In a nutshell, by implementing Blockchain, problems like technological requirements, expertise crisis, business partners' disapproval, system imbalance, the financial risks, and managing legal situations might arise. It is crucial to address these issues before implementing the change into the system on a large scale.

Limitations of Blockchain

The primary challenges of Blockchain technology are scalability, high energy consumption, security, costs, privacy limitations, risk of 51% attack. The modern infrastructure of the supply chain contains many more components. It will not be surprising if a scalability issue rises as the Blockchain expands. Additionally, the processing speed of the blockchain is one of the key concern in implementation. Each block of a Bitcoin blockchain has a size of 1 MB. And, considering the processing of number blocks for every appending transaction, a potent processor

needs enormous energy as well as time. One example is the Red Belly Blockchain. It's a speedy solution capable of performing tens of thousands of transactions per second. Most blockchains currently handle 20 or fewer transactions in that time. Researches are coming up with different solutions to overcome scalability issue, which broadly falls into two categories: storage optimization of Blockchain and redesigning of the Blockchain. The above methods delineate in the explanatory level for now, and no real-time solutions are released.

Private Blockchains aim at addressing the issue of security due to the transparent nature of transactions. Expertise is required while designing a Blockchain framework for industry to carefully choose the level of transparency they need while securing sensitive information. However, the current production is lagging in people with both domain and Blockchain expertise.

All members approve each Blockchain transactions of the blockchain network. Hence, the more extensive the system, more time and energy is consumed for each operation to be verified and posted. Involvement of higher time, energy, and processing power results in higher expenditures that is one of the primary focus areas in blockchain research.

Exposure to all the information to all the stakeholders in the supply chain, the security of the individual can be compromised. With a transparent network like blockchain, information outflow to competitors in the market can be a threat. Sharing information within the chain needs a high level of understanding of the privacy issues, and skills design the blockchain accordingly.

This research paper considers all the above factors as a roadblock to Blockchain adoption and need to address before Blockchain transforms the industries as food, education, and health.

Theory

Technology Adoption Lifecycle

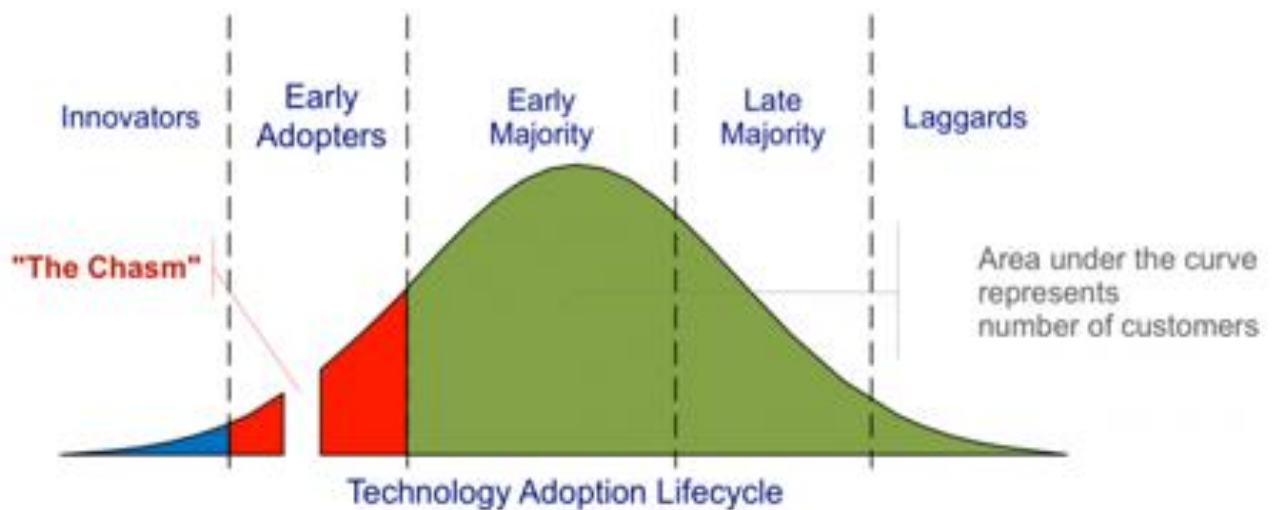


Fig 2: Technology Adoption Lifecycle

Image Source: Wikipedia – Technology Adoption Lifecycle

Any new technology goes through the Technology Adoption Lifecycle; a sociological model developed from the diffusion model (by Joe M. Bohlen, George M. Beal, and Everett M. Rogers). According to this model, every technology observes five phases, as shown in fig 2. After the invention and its early adoption by few, any technology faces a gap in adoption cycle called “The Chasm.” The gap is due to the perceived risk involved in the early adoption of technology. On a positive side, early adopters have a competitive advantage over the technology as compared

to others. Currently, Blockchain is currently observing the chasm, which can be one of the undermining factors affecting the adoption of Blockchain by firms. Chasm effect is one of the hypotheses intended to test in this research and expect to see a positive correlation between the perception of the risk of early adoption and the adoption by the organizations.

The complexity of the Supply Chain:

The complexity of a supply chain increases with the increase in the number of suppliers in the Supply Chain. So is the complexity of making changes to the supply chain. For example, the adoption of Blockchain into the Tuna fish supply was possible because of the smaller number of stakeholders in its supply chain. The transactions are limited, and hence processing with the current capacity of the technology is feasible. Imagine the adoption of blockchain into the dairy industry. There are thousands of providers, suppliers, distributors, retailers, and consumers of different dairy products and managing the entire supply chain with blockchain technology involves millions of transactions. Processing these transactions every day would consume an enormous amount of energy. Besides, the transaction speed is also not accountable with the current blockchain transaction speed. Blockchain should overcome the limitation of scalability before adoption into larger supply chain groups. Scalability can be one of the factors affecting adoption Blockchain by a firm, i.e., the more the number of stakeholders in the Supply Chain, the less likely is the firm in adopting Blockchain technology.

Research Model and Hypothesis

Blockchain until the recent time is confined only to its application in cryptocurrency, Bitcoin to be precise. But, blockchain is more than that, and extensive research is happening to disrupt its benefits in other industries and domains. However, most companies are still skeptical about investing and adopting blockchain. This research study aims to identify the barriers to the adoption of Blockchain in Food industry.

Research question:

“How does the perception of the risk in early adoption, size of the firm, IT investment, and the number of stakeholders in the Supply Chain affect the adoption of Blockchain by a food industry?”

The following are the independent and dependent variables involved in addressing the research question.

Independent variables:

The perception of a firm of the risk of early adoption of the Blockchain, IT investment, size of the firm, and the number of users or stakeholders involved in the Supply Chain.

Dependent variable:

Adoption of Blockchain by a firm (binary).

The following are the hypothesis developed to identify the relation between the dependent and independent variables.

Hypothesis 1a

Lack of clarity and perceived risk of early adoption are undermining factors for Blockchain adoption.

Hypothesis 1b

With the increase in the size of the firm and IT investment, the likeliness of adoption of Blockchain increases.

Hypothesis 1c

The rate of adoption of Blockchain decreases with the increase in the number of people involved in the supply chain.

These hypotheses are aimed to be statistically supported or rejected in the future after successful data collection.

Data and Research Methodology

The construction of theory and hypothesis for this research are from the analysis of available documentation in the area of Blockchain in the Food Supply Chain. The documentation is in the form of journals, articles, books, and blogs. The difficulties in the adoption and the limitations of the Blockchain helped to build the research hypothesis.

The future research intended to test the hypothesis statistically should collect data by developing a set of survey questions and sending across different organizations within the Food Supply Chain. An unbiased analysis is possible by maintaining equal proportions of the small, medium, and large firms in the dataset. The survey questions are developed in a way to be able to scale each variable, either numerically or categorically. Based on the response rate for the survey, interviews can also be conducted to gather required data.

Regression can be used to understand the relation between the dependent and independent variables. In a rudimentary analysis of the binary output variable, i.e., Adoption of the Blockchain, logistic regression can be useful as a primary tool.

Expected Results

The research inputs and operations will work with the aims and objectives to cross-check the hypothesis. A cross-disciplinary approach to the project will have the potential to discover prove the present theory and provide new theoretical openings in the area of the research. This research target to expect the following results. The statistical and logical evidence will support to prove the result prediction.

1. A high significance can be observed for the perceived risk of early adoption to be a prime reason for Blockchain adoption.
2. A positive correlation exists between the size of the firm and the approval of the Blockchain, i.e., larger firms are more likely to adopt Blockchain.
3. Similar to the size of the firm, a positive relationship exists between the IT investment of a firm and its choice of Blockchain adoption.
4. A negative correlation exists between the adoption of Blockchain and the number of stakeholders within the supply chain, i.e., when the number of people within the chain increases, the likeliness to adopt Blockchain decreases.

Conclusion and Future Research

The adoption of Blockchain can build trust by eliminating the opaqueness in the Food Supply Chain. With this tremendous opportunity to revolutionize the food industry, many firms are still skeptical about adopting Blockchain. This paper aims to identify the various factors affecting the adoption of Blockchain by a firm and the type of effect they have (positive, negative, or neutral). A positive relationship is expected between the size of the firm, IT investment, and perception of early adoption risk with the blockchain adoption by a firm. A negative relation expected between the number of stakeholders in the supply chain and the adoption of Blockchain.

Further research and analysis need to be conducted to bolster the hypothesis statistically. Organizations should understand the benefit blockchain can bring and strive towards the adoption of the Blockchain. Furthermore, future research should address the ways to overcome the limitations of the blockchain and attempt towards the adoption of the Blockchain by firms in the Food Supply Chain.

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Appendix I

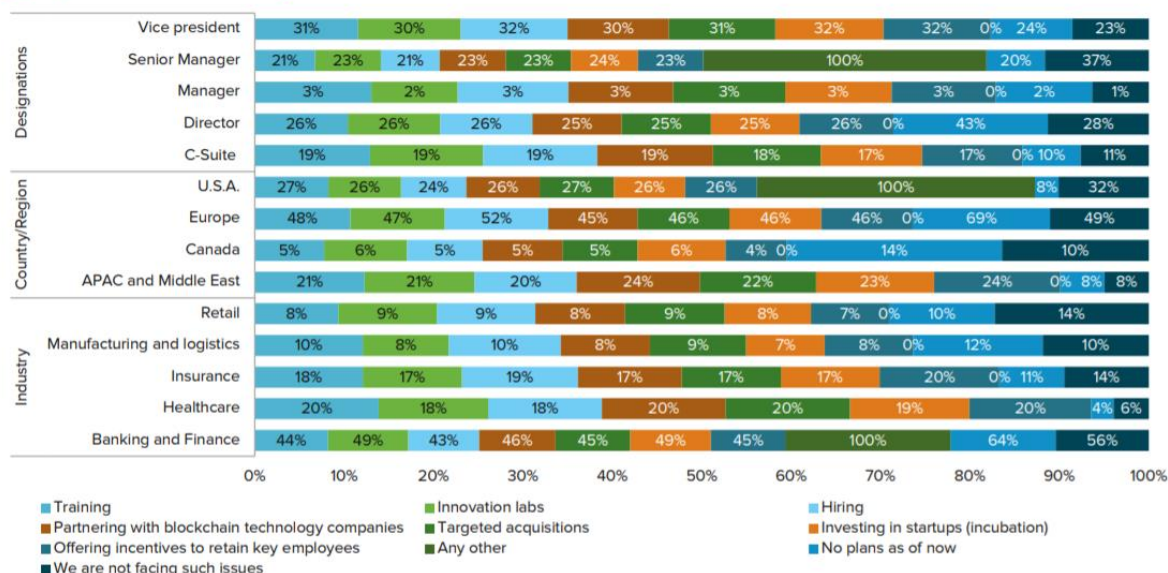
Source:

Cognizant – Blockchain Primary Research – By the number: Blockchain goes global, (Jan 2019)

<https://www.cognizant.com/blockchain-adoption-primary-research>

i) Addressing the skillset gap in Blockchain:

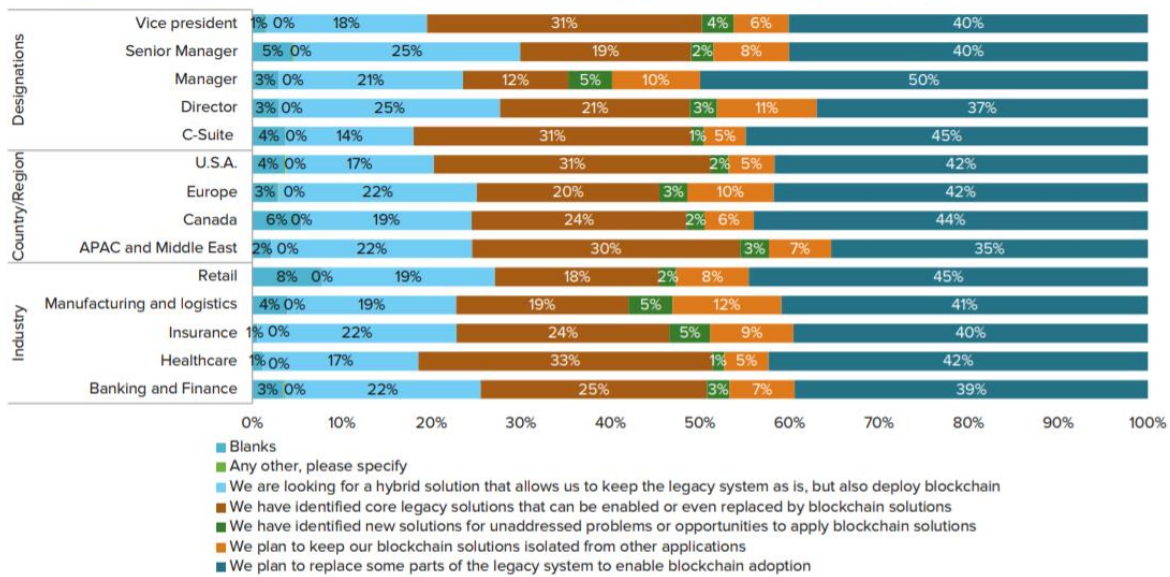
How is your organization addressing the potential skillset gap created by blockchain?



- 37% of Senior Managers and 23% of Vice presidents think they are not facing any issues of skillset gap
- 32% of respondents from USA and 49% of respondents from Europe think they are not facing any issues of skillset gap
- 52% of respondents from Europe are addressing skillset gap by hiring
- 49% of respondents from BFS addressing skillset gap by providing innovation labs

ii) Integrating Blockchain with legacy Systems:

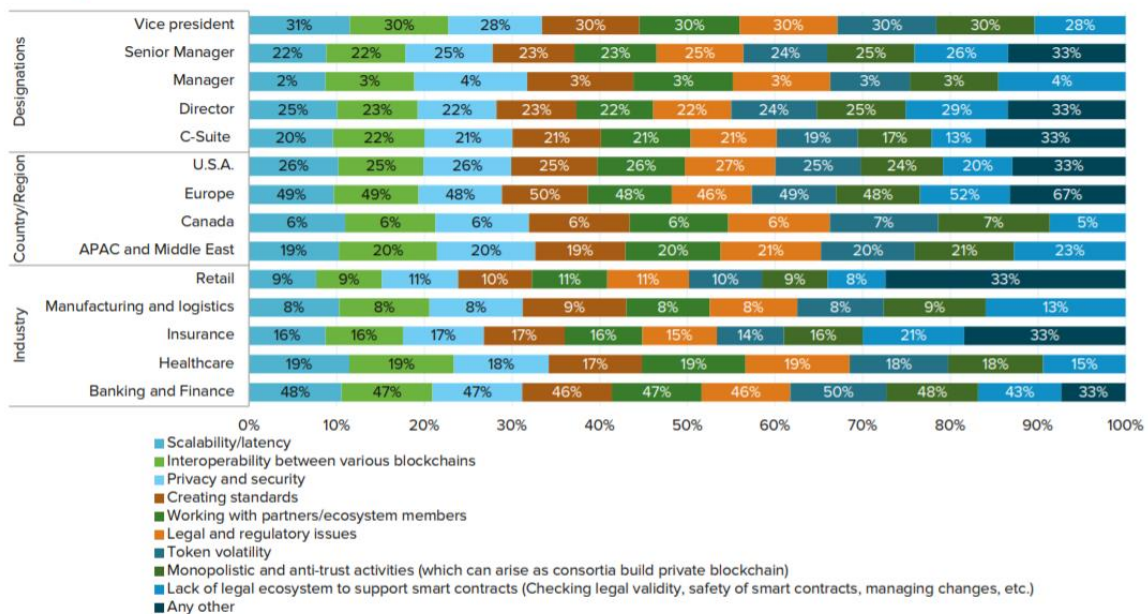
Which of the following best describes your plans for integrating blockchain technology with legacy systems?



- 40% of Senior Managers and 50% of Managers plan to replace some parts of legacy system to enable blockchain adoption
- 42% of respondents from Europe and 44% of respondents from Canada plan to replace some parts of legacy system to enable blockchain adoption
- 45% of respondents from Retail plan to replace some parts of legacy system to enable blockchain adoption

iii) Roadblocks to blockchain adoption:

What are the top five external roadblocks to blockchain adoption?



- 48% of respondents from Europe think, working with partners/ecosystem members is an external roadblock to blockchain adoption
- 48% of respondents from BFS Industry think, scalability/latency to be an external roadblock

Appendix II

Bait-to-plate project by Fijian company:

One of the challenges food industry currently facing is being able to track and identify the origin or provenance of the food and verify the truthful claims made by service providers. Specifically, the seafood industry is making a plethora of money due to a large customer base but have loopholes in tracking, storing and hygiene management systems.

This modern supply chain supported by the World Wide Fund for Nature (WWF) aims to make supply chain system less opaque and more traceable through the idea of ‘Bait-to-plate’ or ‘Boat-to-throat.’ WWF is working along with the group of organizations including Fijian tech start-up TraSeable, a small fishing company called Sea Quest, and a Brooklyn blockchain company called Viant to develop ‘Bait-to-plate’ supply chain using Blockchain. Currently, Sea Quest has completed the first part of the ‘Bait-to-plate’ project by tracing the supply chain from the Sea to the domestic market. However, the challenges mentioned in this research paper but not limited to are hindering the success of ‘Bait-to-plate’ with the help of Blockchain.